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Research Article

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Incubation study of the stromatolyte as a natural source of liming material for management of acid soil

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Summary

The possibility of using the stromatolyte as a soil amendment in an acid soil was investigated. Stromatolyte contained 79 per cent calcium carbonates plus small amount of magnesium and sulphur. An incubation study was conducted with an acid soil upto 50 days and the treatments included various doses of stromatolyte (0.1, 0.2 and 0.3 LR) with and without FYM. Results indicated the application of different doses of stromatolyte raised the pH from 5.1 to 6.2 and maintained from 14th to 28th days of incubation period. But when these different doses of stromatolyte mixed with FYM, it raised the pH from 5.4 to 6.4 and maintained from 21 to 28th days of incubation period.The application of different doses of stromatolyte neutralised the acidity (from 1.13 to 0.62 Cmol (P^+) / kg) , exchangeable Al^{+3} (from 0.60 to 0.43 Cmol (P^+) / kg) and exchangeable H^+ (from 0.50 to 0.19 Cmol (P^+) / kg). But the combine application of different doses of stromatolyte with FYM neutralised the acidity (from 1.08 to 0.54 Cmol(P^+)/kg), exchangeable Al^{+3} (from 0.56 to 0.40 Cmol(P^+)/kg) and exchangeable H^+ (0.49 to 0.04 Cmol (P^+)/ kg) more. The application of ST @ 0.3 LR mixed with FYM raised the pH (6.4) and neutralised the acidity (0.54 Cmol(P^+)/kg), exchangeable Al^{+3} (0.40 Cmol (P^+)/kg) and exchangeable H^+ (0.04 Cmol(P^+)/kg) more compared to the other treatments.

Key words : Stromatolyte, pH, Exchange acidity, Acid soil

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Introduction

Acid soils occupy nearly 3.95 billion ha and account for 30 per cent of the world's ice free land area (Von and Mutert, 1995). In India, the same occupy 90 million ha covering 25 per cent of the total geographical area (Sharma and Sarkar, 2005). In Odisha, the acid soils occupy nearly 70 per cent of the total cultivated area (Mitra *et al.*, 2006).The acidic soils develop physical, chemical, nutritional and biological constraints for crop production in term of soil crusting (affecting seed germination), high infiltration rate, low water holding capacity, high permeability, low pH, low cation exchange capacity, low base saturation, high Al, Fe and Mn saturation percentage, high P fixing capacity (Pattanayak and Mishra,1989), poor availability of essential plant nutrients like Ca, Mg, P, Mo, B and Si, poor microbial activity and biologically mediated nutrient transformation processes, poor N_2 fixation due to poor Rhizobial activity

etc. All these lead to poor root growth, root injury, root discoloration, restricted root branching, damaged root membrane causing poor uptake of plant nutrients.

Restoration of lost basic cations, amelioration of acidity, supplementation of deficient nutrients as per crop requirement, judicious use of chemical fertilizers, proportionate use of organics can help managing acid soils. Liming of acid soil is the way to raise pH, base status, cation exchange capacity, inactive Al, Fe and Mn in soil solution and reduce P fixation (Panda and Koshy, 1982 and Mishra and Pattanayak, 2002).

In the state of Odisha there is large deposit of high grade limestone. These are used for steel industry. Their cost is very high and this cannot be used in agriculture sector. For many subsistent farmers the high cost of lime prevents their use in agriculture (Panda, 2009). In this context, attention has given for the possible exploitation of a natural source of liming materials known as "Stromatolytic Limestone", which is a low grade limestone with high silica content with limited industrial importance and contains 28.32 per cent CaO, 12 per cent MgO and 0.5 per cent P_2O_5 (Misra, 2004 and Pattanayak, 2013). The total reserve of this limestone in Odisha is about 40Mt.

Resource and Research Methods

The stromatolyte was collected from the Nabarangpur district of Odisha. The incubation study of the stromatolyte was done in Khorda soil. Before incubation study the stromatolyte was characterized (Table A).

Table A: Characterization of the stromatolyte

Liming material	Properties (%)			
	•NV	Ca	Mg	S
Stromatolyte	79	17.3	10.5	0.04

•NV- Neutralising value

Table B : Treatment details

T_1	Control	T_5	ST @ 0.2 LR
T_2	FYM	T_6	ST @ 0.2 LR + FYM
T_3	ST @ 0.1 LR	T_7	ST @ 0.3 LR
T_4	ST @ 0.1 LR + FYM	T_8	ST @ 0.3 LR + FYM

The soil samples were collected from the Khorda district of Odisha. The soil samples were dried under shade and processed by the use of 2 mm sieve. Then the sample was kept in a polythene bag. The initial physical and chemical properties were analysed (Table C). The 500 ml beaker was collected in 24 numbers and each beaker was filled up with processed soil. Then the stromatolyte was applied in each beaker based on the treatment except control and FYM treatment. The organic manure (FYM) was also applied based on the treatment like with or without FYM.

Table C : The initial soil properties

Parameters	Methods	Khorda soil
Physical parameters		
Sand (%)		82
Silt (%)	Bouyoucous Hydrometer method by Piper (1950)	10
Clay (%)		8
Texture	Textural triangle	Loamy sand
Order		*Alfisol*
Chemical parameters		
pH_w(1:2.5)	Jackson (1973)	4.4
Organic carbon (g/kg)	Walkley and Black by Page *et al*., 1982	5.5
Available 'N' (kg/ha)	Alkaline $KMnO_4$ method by (Subbiah and Asija,1956)	173
Available 'P' (kg/ha)	Bray's 1 'P' by Page *et al*., 1982	102
Available 'K' (kg/ha)	Neutral normal Ammonium acetate by flame photometer method	135
Available 'S' (kg/ha)	0.15 per cent $CaCl_2$ by turbidimetric method	15
Exchange acidity (Cmol(P^+)/kg)		1.19
Acidity due to Al^{+3} (Cmol(P^+)/kg)	Neutral normal KCL	0.72
Acidity due to H^+ (Cmol(P^+)/kg)		0.47
Lime requirement (t $CaCo_3$/ha)	Woodruff Buffer method	5.9

The soil sampling was done in the 7 days interval from the beaker. These samples were dried under shade, processed and kept in a polythene bag. These processed samples were analysed for pH, exchange acidity, exchangeable Al^{+3} and exchangeable H^{+}. The moisture of the sample in beaker was maintained within two days interval.

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Change in soil reaction (pH) due to the application of stromatolyte during the incubation period :

The initial soil pH was 4.94. During the incubation period there was no change in control treatment but at the 50th days after incubation period (DAI) there was slight decrease in pH which attain a level of 4.2. The application of FYM raised the pH from the level of 4.6 to 4.8, respectively and maintained upto 14th DAI. It is due to the buffering capacity of the soil when FYM was applied to the soil (Table 1 and Fig. 1).

The application of stromatolyte (ST) @ 0.1 LR, it neutralised the acidity (H^{+} and Al^{+3}) and raised the pH from a level of 4.7 upto 5.1 and maintained the higher pH compared to the control and FYM upto 21st DAI then decreased, thereafter, to the pH level of 4.4 by the 50th DAI. However, integrated use of ST @ 0.1 LR with FYM, its neutralisation capacity was more compared to the application of ST @ 0.1 LR alone. It raised the pH from the level of 4.9 upto 5.4 and maintained for 28th DAI (Table 1 and Fig.1).

The double dose of the stromatolyte (ST @ 0.2 LR) was effective to neutralised the acidity and raised the pH upto 5.9. It maintained the higher pH at the 28th DAI period compared to the ST @ 0.1 LR. However, the combining application of ST @ 0.2 LR with FYM raised the pH upto 6.1 and maintained for 43rd DAI (Table 1 and Fig.1). The similar results reported by the Jena (2008). He found that application of lime @0.2 LR raised the pH from 5.1 to 6.9 and decreased the exchangeable Al^{+3} from 0.62 to zero Cmol (P^{+}) / kg with in seven days of incubation.

The triple dose of stromatolyte (ST @ 0.3 LR) was more effective compared to the ST @ 0.2 LR which raised the pH upto 6.2 and maintained for 43rd DAI. However, combining use of ST @ 0.3 LR with FYM, it raised the pH upto 6.4 and maintained higher pH compared to the application ST @ 0.3 LR alone for 50th DAI (Table 1 and Fig.1). This result corroborates the findings of Mohammadi (2010).

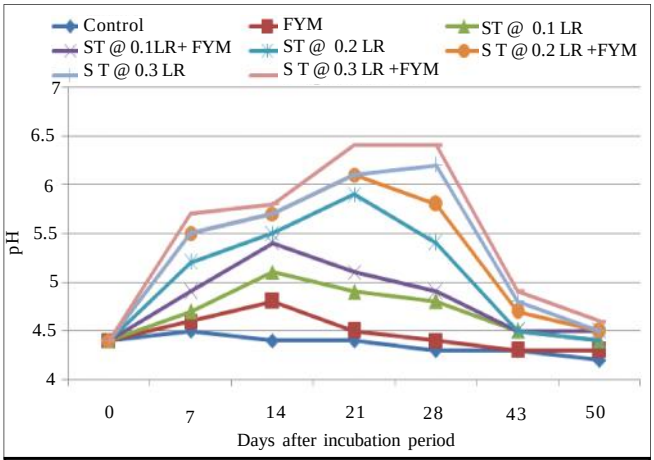

Fig. 1: Graphical representation of the change in soil reaction under the influence of stromatolyte during incubation period

Table 1 : Change in soil reaction due to the influence of stromatolyte

Sr. No.	Treatments	Initial	Days after application					
			7	14	21	28	43	50
1.	Control	4.4	4.5	4.4	4.4	4.3	4.3	4.2
2.	FYM	4.4	4.6	4.8	4.5	4.4	4.3	4.3
3.	ST @ 0.1 LR	4.4	4.7	5.1	4.9	4.8	4.5	4.4
4.	ST @ 0.1 LR + FYM	4.4	4.9	5.4	5.1	4.9	4.5	4.5
5.	ST @ 0.2 LR	4.4	5.2	5.5	5.9	5.4	4.5	4.4
6.	ST @ 0.2 LR + FYM	4.4	5.5	5.7	6.1	5.8	4.7	4.5
7.	ST @ 0.3 LR	4.4	5.5	5.7	6.1	6.2	4.8	4.5
8.	ST @ 0.3 LR + FYM	4.4	5.7	5.8	6.4	6.4	4.9	4.6

•ST = Stromatolyte

Change in exchange acidity (Cmol (P^+) / kg) due to the application of stromatolyte during the incubation period :

The initial exchange acidity in soil was 1.19 (Cmol (P^+)/kg). There was no change in acidity in control treatment during the incubation period. By the application of FYM, it neutralised the acidity (H^+ and Al^{+3} ion) upto 14th DAI *i.e.*, 1.15 (Cmol(P^+)/kg) due to the buffering action of the FYM in the soil. Then increased, thereafter, upto the level of 1.19 (Cmol(P^+)/kg) by 50th DAI (Table 2 and Fig. 2).

The application of the ST @ 0.1 LR neutralised the acidity (H^+ and Al^{+3}) 1.15 (Cmol(P^+)/kg) at 7th days of incubation and maintained up to 1.13 (Cmol (P^+)/kg) at 14th DAI then increased there after over the incubation period. However, the integrating application of ST @ 0.1 LR with FYM neutralised the more as compared to the application of ST @ 0.1 LR alone. It brought down the acidity at 21st DAI *i.e.* 1.13 (Cmol (P^+)/kg) then increased there after over the incubation period (Table 2 and Fig. 2).

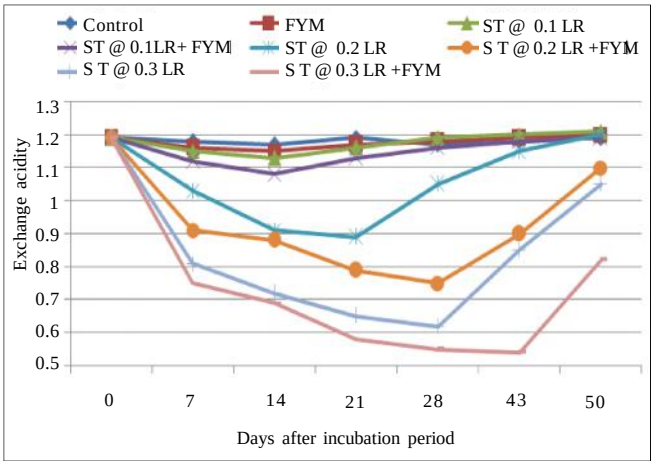

Fig. 2: Graphical representation of the change in exchage acidity under the influence of stromatolyte during incubation period

In treatment ST @ 0.2 LR (double dose), its neutralisation capacity was more as compared to the application of ST @ 0.1 LR (single dose). It neutralised the acidity upto 21 DAI (0.89 Cmol(P^+)/kg) but when it mixed with FYM, it brought down the acidity upto 28th DAI (0.75 Cmol(P^+)/kg) (Table 2 and Fig. 2).

By the application of ST @ 0.3 LR, its neutralisation capacity was more as compared to the ST @ 0.2 LR. It neutralised the acidity up to 28th DAI (0.62 Cmol(P^+)/kg) but when it mixed with FYM it maintained for 43rd DAI (0.54 Cmol(P^+)/kg) (Table 2 and Fig. 2).

Change in exchangeable Al^{+3} (Cmol(P^+)/kg) due to the application of stromatolyte during the incubation period :

The initial exchangeable Al^{+3} was 0.72 Cmol(P^+)/kg. There was no change in exchangeable Al^{+3} in control treatment. By the application of FYM, there was slight neutralisation of exchangeable Al^{+3} was occurred upto 14 DAI *i.e.* (0.69 Cmol(P^+)/kg) then increased, thereafter. (Table 3 and Fig. 3).

The application of ST @ 0.1 LR neutralised the exchangeable Al^{+3} 0.65 Cmol(P^+)/kg at 7th DAI and maintained upto 0.60 Cmol (P^+)/kg at 21st DAI. But the integrated use of ST @ 0.1 LR with FYM, it neutralised the exchangeable Al^{+3} more as compared to the ST @ 0.1 LR alone upto 0.56 Cmol(P^+)/kg at 21st DAI. Then increased there after during the incubation period (Table 3 and Fig. 3).

The double dose of the stromatolyte (ST @ 0.2 LR) neutralised the acidity due to Al^{+3} more as compared to the ST @ 0.1 LR upto 0.52 Cmol(P^+)/kg at 28th DAI but when it mixed with FYM, its neutralisation efficiency was molre *i.e.* 0.50 Cmol(P^+)/kg at 28th DAI (Table 3 and Fig. 3).

The application of ST @ 0.3 LR brought down the acidity due to Al^{+3} was compared to the ST @ 0.2 LR

Table 2 : Change in exchange acidity due to the application of stromatolyte during the incubation period

Sr. No.	Treatments	Initial	Days after application					
			7	14	21	28	43	50
1.	Control	1.19	1.18	1.17	1.19	1.17	1.18	1.19
2.	FYM	1.19	1.16	1.15	1.17	1.18	1.19	1.20
3.	ST @ 0.1 LR	1.19	1.15	1.13	1.16	1.19	1.20	1.21
4.	ST @ 0.1 LR + FYM	1.19	1.12	1.08	1.13	1.16	1.18	1.19
5.	ST @ 0.2 LR	1.19	1.03	0.91	0.89	1.05	1.15	1.20
6.	ST @ 0.2 LR + FYM	1.19	0.91	0.88	0.79	0.75	0.90	1.10
7.	ST @ 0.3 LR	1.19	0.81	0.72	0.65	0.62	0.85	1.05
8.	ST @ 0.3 LR + FYM	1.19	0.75	0.69	0.58	0.55	0.54	0.82

•ST = Stromatolyte

i.e. 0.43 Cmol(P^+)/kg at 28th DAI but combine application of ST @ 0.3 LR with FYM, it neutralised the acidity due to Al^{+3} upto 0.40 Cmol (P^+)/kg at 28th DAI then gradually increased there after (Table 3 and Fig. 3).

Change in exchangeable H^+ (Cmol(P^+)/kg) due to the application of stromatolyte during the incubation period :

The initial status of the exchangeable H^+ was 0.47 Cmol (P^+) / kg. In control and FYM treatment, there was slight reduction in exchangeable H^+ upto 14th DAI *i.e.* o.44 and 0.46 Cmol (P^+)/kg the gradually decreased, thereafter (Table 4 and Fig. 4).

There were increasing in exchangeable H^+ in ST @ 0.1 LR and ST @ 0.1 LR mixed with FYM treatment instead of decreasing of exchangeable H^+. But the double dose of stromatolyte (ST @ 0.2 LR) neutraliserd the acidity due to H^+ upto 21th DAI (0.36 Cmol(P^+)/kg) and

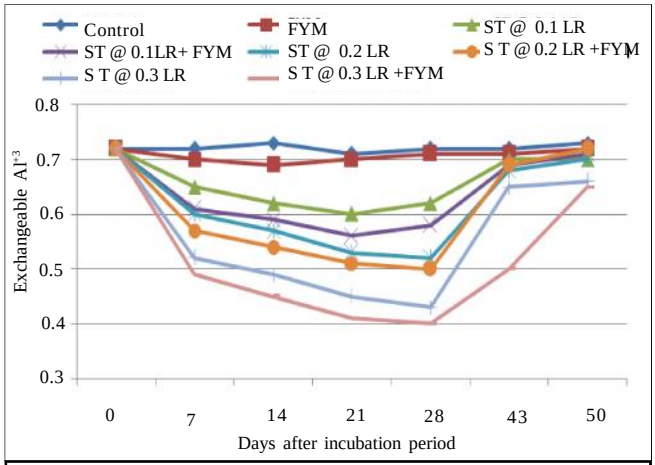

Fig. 3: Graphical representation of the change in exchageable Al^{+3} under the influence of stromatolyte during incubation period

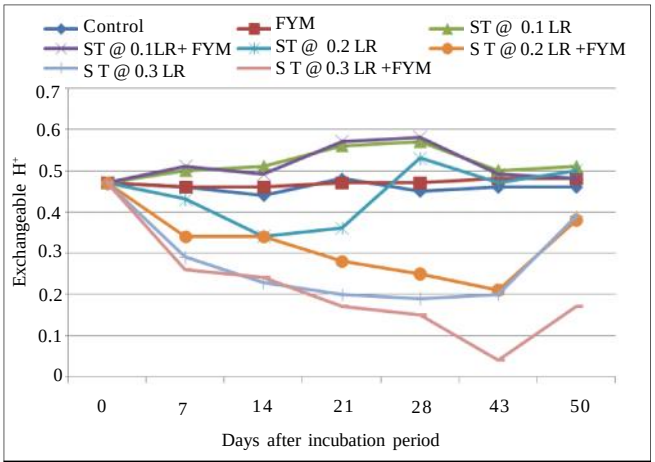

Fig. 4: Graphical representation of the change in exchageable H^+ under the influence of stromatolyte during incubation period

Table 3 :Change in exchangeable Al^{+3} due to the application of stromatolyte during the incubation period

Sr. No.	Treatments	Initial	Days after application					
			7	14	21	28	43	50
1.	Control	0.72	0.72	0.73	0.71	0.72	0.72	0.73
2.	FYM	0.72	0.70	0.69	0.70	0.71	0.71	0.72
3.	ST @ 0.1 LR	0.72	0.65	0.62	0.60	0.62	0.70	0.70
4.	ST @ 0.1 LR + FYM	0.72	0.61	0.59	0.56	0.58	0.69	0.71
5.	ST @ 0.2 LR	0.72	0.60	0.57	0.53	0.52	0.68	0.70
6.	ST @ 0.2 LR + FYM	0.72	0.57	0.54	0.51	0.50	0.69	0.72
7.	ST @ 0.3 LR	0.72	0.52	0.49	0.45	0.43	0.65	0.66
8.	ST @ 0.3 LR + FYM	0.72	0.49	0.45	0.41	0.40	0.50	0.65

•ST = Stromatolyte

Table 4 :Change in exchangeable H^+ due to the application of stromatolyte during the incubation period

Sr. No.	Treatments	Initial	Days after application					
			7	14	21	28	43	50
1.	Control	0.47	0.46	0.44	0.48	0.45	0.46	0.46
2.	FYM	0.47	0.46	0.46	0.47	0.47	0.48	0.48
3.	ST @ 0.1 LR	0.47	0.50	0.51	0.56	0.57	0.50	0.51
4.	ST @ 0.1 LR + FYM	0.47	0.51	0.49	0.57	0.58	0.49	0.48
5.	ST @ 0.2 LR	0.47	0.43	0.34	0.36	0.53	0.47	0.50
6.	ST @ 0.2 LR + FYM	0.47	0.34	0.34	0.28	0.25	0.21	0.38
7.	ST @ 0.3 LR	0.47	0.29	0.23	0.20	0.19	0.20	0.39
8.	ST @ 0.3 LR + FYM	0.47	0.26	0.24	0.17	0.15	0.04	0.17

•ST = Stromatolyte

when it mixed with FYM, it neutralised the acidity due to H^+ more as compared to the ST @ 0.2 LR alone upto 28th DAI (0.25 Cmol(P^+)/kg) (Table 4 and Fig. 4).

The triple dose of the stromatolyte (ST @ 0.3 LR) neutralised the acidity due to H^+ upto 43rd DAI (0.20 Cmol(P^+)/kg) but the combined application of ST @ 0.3 LR with FYM neutralised the acidity same *i.e*. 43th DAI (0.04 Cmol(P^+)/kg) (Table 4 and Fig. 4).

These results indicate that combined use of inorganic and organic ameliorants are essential for neutralising the acidity. There is scope for increasing efficiency of the lime sources, particularly the indigenous source i.estromatolyte. Earlier Pattanayak and Pandey (2012) reported for the application of stromatolyte @ 0.1 LR with FYM of 22 mesh sieve size for better effectiveness.

Conclusion :

Results indicated that there was no change in control treatment but the application of FYM, increased the pH and neutralised the acidity, acidity due to Al^{+3} and acidity due to H^+ slightly. The application of different doses of stromatolyte raised the pH from 5.1 to 6.2 and maintained from 14th to 28th days of incubation period. But when these different doses of stromatolyte mixed with FYM, it raised the pH from 5.4 to 6.4 and maintained from 21 to 28th days of incubation period.The application of different doses of stromatolyte neutralised the acidity (from 1.13 to 0.62 Cmol (P^+)/kg), exchangeable Al^{+3} (from 0.60 to 0.43 Cmol(P^+) /kg) and exchangeable H^+ (from 0.50 to 0.19 Cmol(P^+) /kg). But the combine application of different doses of stromatolyte with FYM neutralised the acidity (from 1.08 to 0.54 Cmol (P^+) /kg), exchangeable Al^{+3} (from 0.56 to 0.40 Cmol (P^+) /kg) and exchangeable H^+ (0.49 to 0.04 Cmol(P^+) /kg) more. The application of ST @ 0.3 LR mixed with FYM raised the pH (6.4) and neutralised the acidity (0.54 Cmol (P^+) /kg), exchangeable Al^{+3} (0.40 Cmol(P+)/ kg) and exchangeable H^+ (0.04 Cmol (P^+) /kg) more compared to the other treatments.

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